

## Gas Stoichiometry

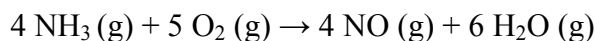
### Practice Problems:

- 1) Calculate the average molar mass of dry air if it has a density of 1.17 g/L at 21°C and 740.0 torr.

$$d = 1.17 \frac{g}{L}; P = 740.0 \text{ torr} = 0.97 \text{ atm}; T = 21^\circ\text{C} = 294 \text{ K}; R = 0.0821 \text{ Latm/Kmol}$$

$$MM = \frac{dRT}{P} = \frac{\left(1.17 \frac{g}{L}\right) \left(0.0821 \text{ Latm/Kmol}\right) (294 \text{ K})}{0.97 \text{ atm}} = 29.1 \text{ g/mol}$$

- 2) In the first step in the industrial process for making nitric acid, ammonia reacts with oxygen in the presence of a suitable catalyst to form nitric acid and water vapor:



How many liters of  $\text{NH}_3$  at 850°C and 5.00 atm are required to react with 1.00 mol of  $\text{O}_2$  in this reaction?

$$\left(\frac{1.0 \text{ mol O}_2}{1}\right) \left(\frac{4 \text{ mol NH}_3}{5 \text{ mol O}_2}\right) = 0.80 \text{ mol NH}_3$$

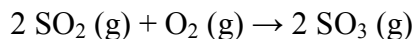
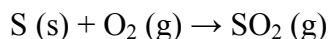
$$P = 5.00 \text{ atm}; T = 850^\circ\text{C} = 1123 \text{ K}; R = 0.0821 \text{ Latm/Kmol}$$

$$V = \frac{nRT}{P} = \frac{(0.80 \text{ mol})(1123 \text{ K})(0.0821 \text{ Latm/Kmol})}{5.00 \text{ atm}} = 14.8 \text{ L}$$

- 3) A student adds 4.00 g of dry ice (solid  $\text{CO}_2$ ) to an empty balloon. What will be the volume of the balloon at STP after all the dry ice sublimates (converts to gaseous  $\text{CO}_2$ )?

$$\left(\frac{4.00 \text{ g}}{1}\right) \left(\frac{1 \text{ mol}}{44.01 \text{ g}}\right) \left(\frac{22.4 \text{ L}}{1 \text{ mol}}\right) = 2.03 \text{ L}$$

- 4) Sulfur trioxide,  $\text{SO}_3$ , is produced in enormous quantities each year for use in the synthesis of sulfuric acid:



What volume of  $\text{O}_2$  at 350°C and a pressure of 5.25 atm is needed to completely convert 5.00 g of sulfur to sulfur trioxide?



$$\left( \frac{5.00 \text{ g S}}{1 \text{ mol}} \right) \left( \frac{1 \text{ mol}}{32.06 \text{ g}} \right) \left( \frac{2 \text{ mol O}_2}{1 \text{ mol S}} \right) = 0.312 \text{ mol}$$

$$P = 5.25 \text{ atm}; T = 350^\circ\text{C} = 623 \text{ K}; R = 0.0821 \text{ Latm/Kmol}$$

$$V = \frac{nRT}{P} = \frac{(0.312 \text{ mol})(0.0821 \text{ Latm/Kmol})(623 \text{ K})}{5.25 \text{ atm}} = 3.04 \text{ L}$$

5) (a) Calculate the density of sulfur hexafluoride gas at 678 torr and 28°C.

$$P = 678 \text{ torr} = 0.892 \text{ atm}; T = 28^\circ\text{C} = 301 \text{ K}; R = 0.0821 \text{ Latm/Kmol}; MM = 146.06 \text{ g/mol}$$

$$d = \frac{PMM}{RT} = \frac{(0.892 \text{ atm}) \left( 146.06 \frac{\text{g}}{\text{mol}} \right)}{(0.0821 \text{ Latm/Kmol})(301 \text{ K})} = 5.27 \text{ g/L}$$

(b) Calculate the molar mass of a vapor that has a density of 7.135 g/L at 12°C and 743 torr.

$$d = 7.135 \frac{\text{g}}{\text{L}}; T = 12^\circ\text{C} = 285 \text{ K}; P = 743 \text{ torr} = 0.98 \text{ atm}; R = 0.0821 \text{ Latm/Kmol}$$

$$MM = \frac{dRT}{P} = \frac{(7.135 \frac{\text{g}}{\text{L}})(0.0821 \text{ Latm/Kmol})(285 \text{ K})}{0.98 \text{ atm}} = 170 \text{ g/mol}$$